PROTOCOL
FOR
MONITORING EFFECTIVENESS
OF
IN-STREAM HABITAT PROJECTS

(Channel Reconfiguration, Deflectors, Log and Rock Control Weirs, Roughened Channels, and Woody Debris Removal)

MC-2

Washington Salmon Recovery Funding Board

April 2004

Willapa Bay RFEG; Mid-Trap Creek (#01-1229)
05/07/2003. Attachment #13. LWD Placement

Prepared by
Bruce A. Crawford
Project Manager

Laura E. Johnson, Director

Interagency Committee for Outdoor Recreation
1111 Washington Street
PO Box 40917
Olympia, Washington
98504-0917

www.iac.wa.gov

TABLE OF CONTENTS

ACKNOWLEDGMENTS

The Salmon Recovery Funding Board would like to thank the Independent Science Panel and Steve Leider of the Governor's Salmon Recovery Office for their review and helpful suggestions for the experimental design.

We would like to acknowledge the assistance of Leska Fore of "Statistical Designs," who provided consultation for structuring statistical tests and in estimating sample size.

We would also like to acknowledge the assistance of Phil Larsen and Phil Kauffman of the U.S Environmental Protection Agency for providing assistance in developing protocols and in providing estimates of variances associated with EMAP response variables.

Thanks is also extended to George Pess of NOAA Fisheries, and Bill Ehinger, Washington Department of Ecology, for their assistance and critique of the procedure.

We would also like to acknowledge the assistance and review of various lead entity staff for their input and concerns.

ORGANIZATION

Instream habitat improvements are popular habitat restoration projects. They have accounted for 35% of all SRFB restoration projects and 39% of the funding. They have the potential to create improvements in fish habitat by creating cover and improving stream morphology in a short time (1-5 years). This document details the monitoring design and procedures necessary to document and report reach scale effectiveness of projects treating:

- **Channel Reconfiguration**
- **Installed Deflectors**
- **Log and Rock Control weirs**
- **Roughened Channels**
- **Woody Debris**

This document is in compliance with the Washington Comprehensive Monitoring Strategy (Crawford et al. 2002)

The "Procedures and Design" assists project applicants in setting clear measurable goals and objectives when planning a salmon recovery project and also assists the SRFB monitoring entity in evaluating whether instream projects at the reach scale are effective.

The objective for instream projects is to increase instream cover, spawning, and resting areas by constructing artificial instream structures. The basic assumption is creating more diverse pools, riffles, and hiding cover will result in an increase in local fish abundance.

MONITORING GOAL

Determine if projects that place artificial instream structures (AIS) into streams are effective in improving stream morphology and increasing local fish abundance in the treated area at the stream reach level.

QUESTIONS TO BE ANSWERED

Have AIS as designed remained in the stream for up to ten years for the sampled instream structure projects?

Has stream morphology improved significantly in the treated stream reach for the sampled instream structure projects within ten years?

Has juvenile salmon abundance increased significantly in the impact area for the sampled instream structure projects within ten years?

NULL HYPOTHESIS

Placement of AIS in the stream has had no effect upon:

- Improving stream morphology and fish habitat as measured by Thalweg residual pool vertical profile area (AREASUM) and mean residual depth (RP100).
- Increasing juvenile abundance in the impacted area.

OBJECTIVES

BEFORE PROJECT OBJECTIVES (YEAR 0)

Determine the Thalweg Profile in the impact and control areas for each of the instream structure projects sampled.

Determine the numbers of juveniles of the targeted salmon species in the control and impact areas for each of the instream structure projects sampled.

AFTER PROJECT OBJECTIVES (YEARS 1, 3, 5, AND 10)

Determine the number and location of AIS within the treated area for the sampled instream structure projects.

Determine the Thalweg Profile in the control and impact areas for the sampled instream structure projects.

Determine the numbers of juveniles of the target salmon species within the control and impact areas for the sampled instream structure projects.

RESPONSE INDICATORS

Level 1-- Number of AIS remaining in the sampled reach. AIS must be identified using GPS coordinates and other techniques such as tags affixed to LWD in order to track the life of AIS over time. AIS sampling methods are found on page 13.

AIS indicator

Indicator Abbreviation	Description
AIS	Measure of the number of instream structures within the study reach

Level 2-- Thalweg Profile. The Thalweg profile characterizes pool-riffle relationships, sediment deposits, wetted width substrate characteristics, and channel unit-pool forming categories. Stream morphology sampling methods are taken from EMAP (Peck et al. unpubl.), Section 7.4. Protocols summarizing EMAP Table 7-3 and 7-4 are found on pages 14, 16 and 19. Sampling is based upon establishing 11 regular transects within each identified stream reach. Pre-project measures of the variation of depth throughout the stream reach and the residual pool volume will be compared to detect post-project changes.

Thalweg response indicators

Indicator Abbreviation	Description
AREASUM	Mean Thalweg vertical profile area for the study reach
RP100	Mean Thalweg residual depth within the study reach
Log10V1WM100	Volume of large woody debris of all sizes within the study reach
STRMLGTH	Affected stream length includes meander length directly affected by the project
CREACHLGTH	The length of the stream control reach actually sampled
CREACHWIDTH	The average stream width of the control reach actually sampled
IREACHLGTH	The length of the stream Impact reach actually sampled
IREACHWIDTH	The average stream width of the Impact reach actually sampled

Level 3-- Numbers of juvenile salmon in the reach. Abundance of salmon can be determined using juvenile counts. Juveniles will be monitored using protocols developed by Washington Department of Fish and Wildlife and Oregon Department of Fish and Wildlife. Juvenile estimating procedures are found on pages 24 and 26 . The least intrusive monitoring protocol should be used whenever possible. Impact areas will be compared to the controls and to controls and impacts on other streams as well. The metrics used will be numbers per square meter for juveniles.

Fish abundance response variables

Indicator Abbreviation	Description
CHINJV	Measure of juvenile chinook 0 and yearling abundance within the study reach
COHOJV	Measure of coho yearling abundance within the study reach
SHPARR	Measure of steelhead yearling abundance within the study reach

MONITORING DESIGN

Due to the inter-annual variance in habitat and fish parameters, it is anticipated that at least 10 projects should be sampled in order to provide adequate statistical power to detect change. Approximately 21 instream projects have been funded annually by the SRFB. The SRFB intends to monitor 10 randomly selected projects taken from Round 4 and Round 5.

The Board will employ a Before and After Control Impact (BACI) experimental design to test for changes associated with instream structures (Stewart-Oaten et al. 1986). A BACI design samples the control and impact simultaneously at both locations at designated times before and after the impact has occurred. For this type of restoration, placing instream structures would be the impact, that is, the location impacted by the restoration action, and a location upstream of the instream structures would represent the control.

For stream morphology and fish abundance, the BACI design tests for changes at the instream structures impact reach *relative to* the changes in stream morphology and fish abundance observed at a control site upstream. This type of design is required when external factors (e.g., ocean conditions and harvesting) affect the population abundances at the control sites. The object is to see whether the difference between upstream (control) and downstream (impact) abundances and stream morphology has changed as a result of the AIS projects. The presence of multiple projects with control and impact locations will address the concerns detailed by Underwood (1994) regarding pseudo-replications. It is also not considered cost effective to employ multiple control locations for each passage project as recommended by Underwood. Although the ideal BACI would have multiple years of before data as well as after data, this was not possible with locally sponsored projects where there is a need and desire to complete their project as soon as possible.

The plan is to compare the most recent time period of sampling with Year 0 conditions before the projects. A paired *t*-test will be used to test for differences between control (upstream) and impact (downstream) sites during the most recent impact year and Year 0. In other words, we first compute the difference between the control and impact and use those values in a paired *t*-test. This test assumes that differences between the control and impact sites are only affected by the placing of instream structures and that external influences affect population abundance and stream morphology in the same way at both the control and impact sites. The paired sample *t*-test does not have the same assumptions for normality and equality of variances of the two-sample *t*-test but only requires that the differences be approximately normally distributed. In fact, the paired-sample test is really equivalent to a one-sample *t*-test for a difference from a specified mean value.

To implement the design, we will monitor instream structures projects funded in 2003 under Round 4, and projects selected in 2004 under Round 5. This will provide 10 total projects to test for effectiveness. The number of projects proposed for funding in each category will be based upon the calculated sample size needed to obtain statistically significant information in the shortest amount of time. If there are insufficient projects funded in any one year to obtain a proper sample size, then replicates of the design will be used in multiple years until the critical sample size is reached.

The variance associated with impact and control areas will not be known until sampling has occurred in Year 0 of both impact and control areas. After Year 0, a better estimate of the true sample size needed to detect change will be available. Cost estimates and sampling replicates may need to be adjusted at that time.

At the end of the effectiveness monitoring testing, there will be one year of “Before” impact information for all projects for both control and impact areas, and multiple years of “After” impact information for the same control and impact areas for each of the projects.

Depending upon circumstances, the results may also be tested for significance, using a linear regression model of the data points for each of the years sampled and for each of the indicators tested.

Testing for significant trends can begin as early as Year 1. Final sampling may be completed in 2015 for Round 4 projects and 2016 for Round 5 projects.

DECISION CRITERIA

Effective if 80% or more of the AIS structures are present on Year 10. On an individual project basis the project is “intact” if 50% or more of the structure is in place.

Effective if a change of 20% or more is detected for measures of the mean Thalweg residual pool vertical profile area (AREASUM) and mean residual depth (RP100) between the calculated difference between the paired impact and control areas by Year 10 at the Alpha =0.10 level.

Effective if a change of 20% or more is detected for salmon abundance of juveniles between the calculated difference between the paired impact and control areas by Year 10 at the Alpha =0.10 level.

Table 1. Decision criteria and statistical test type

Habitat	Indicators	Metric	Test Type	Decision Criteria
Structure	Measure of the number of instream structures within the study reach (AIS)	#	None. Count of intact structures	≥ 80% of projects are intact by Year 10. Intact means that 50% of material of each AIS is in place within the impact reach.
Stream Morphology	Mean residual pool vertical profile area (AREASUM)	m^2	Linear Regression or Paired *t*-test	Alpha =0.10 for one-sided test. Detect a minimum 20% change between Treatment and control by Year 10
	Mean residual depth. (RP100)	cm	Linear Regression or Paired *t*-test	Alpha =0.10 for one-sided Alpha =0.10 for one-sided test. Detect a minimum 20% change between Treatment and control by Year 10
	Large Wood (Log 10 (V1WM100)	m^3	Linear Regression Paired *t*-test	Alpha =0.10 for one-sided test. Detect a minimum 20% change between Treatment and control by Year 10
Juvenile Fish Abundance	Chinook juvenile abundance (CHINJUV)	#/m2	BACI Paired *t*-test	Alpha =0.10 for one-sided test. Detect a minimum 20% change between Treatment and control by Year 10
	Coho juvenile abundance (COHOJUV)	#/m2	BACI Paired *t*-test	Alpha =0.10 for one-sided test. Detect a minimum 20% change between Treatment and control by Year 10
	Steelhead juvenile abundance (SHJUV)	#/m2	BACI Paired *t*-test	Alpha =0.10 for one-sided test. Detect a minimum 20% change between Treatment and control by Year 10

SAMPLING

SELECTING SAMPLING REACHES

IMPACT AREAS

AIS placement impact areas are often not very large and will be measured in their entirety or sampled according to the methods described on page 13.

CONTROL AREAS
A control reach upstream of each project site should be selected in the same manner as the impact reach. The control should be of equal size and distance immediately upstream of the project site in habitat of similar quality and description.

BEFORE PROJECT SAMPLING
All AIS projects identified for long-term monitoring by the SRFB must have completed Pre-Project Year 0 monitoring prior to beginning the project.

Year 0 monitoring will consist of:

- Determining the linear distance in kilometers to the nearest tenth to be treated with AIS.
- Determine the extent and size of LWD in the impact and control areas. Although large woody debris may not be present, its effect upon stream morphology can be dramatic. It should be tracked to ensure changes observed are a result of AIS and not naturally deposited large woody debris.
- Determine the stream morphology characteristics within the project impact and control areas.
- Determine the abundance of juvenile salmon in the impact and control areas.

AFTER PROJECT SAMPLING
Upon completion of the project AIS placement, Years 1, 3, 5, and 10 monitoring will consist of:

- Identify and enumerate all AIS.
- Determine the extent and size of LWD in the impact and control areas.
- Determine the stream morphology characteristics within the project impact and control areas.
- Determine the abundance of juvenile salmon in the impact and control areas.

METHOD FOR LAYING OUT CONTROL AND IMPACT STREAM REACHES FOR WADEABLE STREAMS

Protocol taken from: ***Peck et al. (Unpubl.), pp. 63-65, Table 4-4; Mebane et al. (2003)***

EQUIPMENT

Metric tape measure, surveyor stadia rod, handheld GPS device, 3 - 2 ft. pieces of rebar painted bright orange, engineer flagging tape, waterproof markers

SAMPLING CONCEPT

The concept of EMAP sampling is that randomly selected reaches located on a stream can be used to measure changes in the status and trends of habitat, water quality, and biota over time if taken in a scientifically rigorous manner per specific protocols. We have applied the EMAP field sampling protocols for measuring effectiveness of restoration and acquisition projects. Instead of a randomly selected stream reach, the stream reach impacted by the project is sampled. These “impact” areas have been matched with “control” areas of the same length and size on the same stream whenever possible.

Within each sampled project reach a series of transects A-K are taken across the stream and riparian zone as points of reference for measuring characteristics of the stream and riparian areas. The transects are then averaged to obtain an average representation of the stream reach.

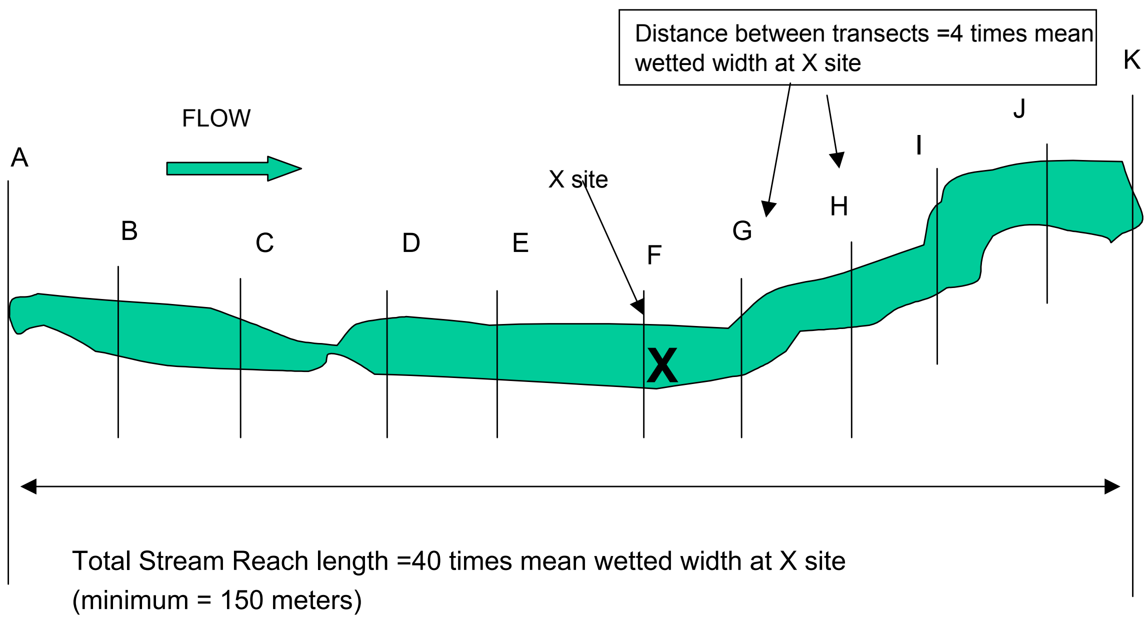

Figure 1. Sampled project reach

LAYING OUT THE TREATMENT AND CONTROL STREAM REACHES

Step 1: Using a handheld GPS device, determine the location of the **X sites** and record latitude and longitude of same on waterproof sheets. The X sites should be considered the center of the impact and control study reach. The Impact reach X site must fall within the project affected area. The location of the control X site should be determined based upon the project category and associated procedure (MC-1 to MC-10). Mark the X site on the bank above the high water mark with one of the rebar stakes so that the X site can be found in future years. Use a surveyor's rod or tape measure to determine the wetted width of the channel at five places considered to be of "typical" width within approximately five channel widths upstream and downstream of the X site sample reach location. For streams less than 4 m in width the reach should be at minimum 150 m.

Step 2: Check the condition of the stream upstream and downstream of the X site by having one team member go upstream and one downstream. Each person proceeds until they can see the stream to a distance of 20 times the stream width (equal to one half the sampling reach length) determined in Step 1.

For example if the reach length is determined to be 150 m, each person would proceed 75 m from the X site to lay out the reach boundaries.

NOTE: *For restoration projects less than 40 stream widths, the entire project's length should be sampled and a control area of similar size should likewise be developed within the treatment stream either upstream or downstream as appropriate.*

Step 3: Determine if the reach needs to be adjusted around the X site due to confluences with lower order streams, lakes, reservoirs, waterfalls, or ponds. Also adjust the boundaries to end and begin with the beginning of a pool or riffle, but not in the center of the pool or riffle. Hankins and Reeves (1988) have shown that measures of the variance of juvenile fish populations is decreased by using whole pool/riffles in the sample area.

Step 4: Starting back at the X site, measure a distance of **20 channel widths** down one side of the stream using a tape measure. Be careful not to cut corners. Enter the channel to make measurements only when necessary to avoid disturbing the stream channel prior to sampling activities. This endpoint is the downstream end of the reach and is flagged as transect "A".

Step 5: Using the tape, measure 1/10th (4 channel widths in big streams or 15 m in small streams) of the required stream length upstream from the start point (transect A). Flag this spot as the next cross section or transect (transect B).

Step 6: Proceed upstream with the tape measure and flag the positions of nine additional transects (labeled "C" through "J" as you move upstream) at intervals equal to 1/10th of the reach length.

METHOD FOR QUANTIFYING ARTIFICIALLY PLACED INSTREAM STRUCTURES (AIS)

Modified Protocol taken from: ***Peck et al. (Unpubl.), pp. 115-117***

PURPOSE

These methods are used to tally “artificially placed instream structures” (AIS). The tally includes all AIS that are in the baseflow channel (the active channel). The active, or bankfull, channel is defined as the channel that is filled by moderate sized flood events that typically occur every one or two years. AIS in the active channel is tallied over the entire length of the reach, including between the channel cross-section transects.

EQUIPMENT

Waterproof field forms, metal tags, hand-held GPS device.

PROCEDURE

Note: *Tally AIS within each segment of stream at the same time the Thalweg profile is being determined. Include all pieces whose large end is located within the segment in the tally.*

Step 1: After all AIS have been placed into the treatment reach and secured in place, inventory the number of pieces and mark their location using a GPS device.

Step 2: Mark each piece of AIS with a metal plate or tag that will be able to resist flooding and other kinds of abrasion over a 10-year period with a unique identifier tag and record the number for future reference.

Step 3: Repeat this procedure for all stream reaches sampled.

TESTING FOR SIGNIFICANT CHANGES IN THE AMOUNT OF ARTIFICIALLY PLACED STRUCTURE

The intent is that AIS remain in place unchanged during Year 1, 3, 5, and 10. In this case, 100% of AIS has remained as designed. On the other hand, some of the AIS may have moved from its original position and is either at a different location within the impact reach, or has been carried downstream to an unknown location. We can determine what proportion of the AIS remains in the impact reach in Years 1, 3, 5, and 10. We can determine what proportion has moved and no longer remains in the sampled reach. These proportions can be compared for each of the tested years. A reduction of 50% or more of the AIS within the study reach would be considered a failure of the AIS and it would no longer be considered intact.

METHOD FOR MEASURING LARGE WOODY DEBRIS (LWD)

Modified Protocol taken from: ***Peck et al. (Unpubl.), pp. 115-117, Table 7-5; Kauffman et al. (1999)***

PURPOSE

These methods are used to tally "large woody debris" (LWD). The tally includes all LWD that are in the bankfull channel (the active channel), or spanning above the active channel. The active, or bankfull, channel is defined as the channel that is filled by moderate-sized flood events that typically occur every one or two years. LWD in the active channel is tallied over the entire length of the reach, including between the channel cross-section transects.

EQUIPMENT

Measuring tape, meter stick, waterproof sampling forms.

SAMPLING DURATION

Counts should be taken during summer low flow in conjunction with other instream measurements such as Thalweg profile.

PROCEDURE

Note: *Tally pieces of LWD within each segment of stream at the same time the Thalweg profile is being determined. Include all pieces whose large end is located within the segment in the tally.*

Step 1: Scan the stream segment between the two cross section transects where Thalweg profile measurements are being made.

Step 2: Tally all LWD pieces within the segment that are at least partially within the bankfull channel. Determine if a piece is LWD (small end diameter 10cm (4 in.); length 1.5 m (5 ft.).

Step 3: For each piece of LWD, determine the class based on the diameter of the large end

- 0.1 m < 0.3 m [4 in < 12 in]
- 0.3 m < 0.6 m [12 in < 24 in]
- 0.6 m < 0.8 m [24 in < 32 in]
- > 0.8 m [> 32 in]

and for the length of the piece

- 1.5 m < 5.0 m [5 ft. < 17 ft.]
- 5.0 m < 15 m [17 ft. < 50 ft.]
- > 15 m [> 50 ft.]

If the piece is not cylindrical, visually estimate what the diameter would be for a piece of wood with circular cross section that would have the same volume.

When estimating length, include only the part of the LWD piece that has a diameter greater than 10 cm (4 in.).

Step 4: Place a tally mark in the appropriate diameter X length class tally box in the "PIECES ALL/PART IN BANKFULL CHANNEL" section of the Thalweg Profile and Woody Debris Form.

Step 5: Tally all LWD pieces within the segment that are not actually within the bankful channel, but are at least partially spanning (bridging) the channel. For each piece, determine the class based upon the diameter of the large end and the class based on the length of the piece.

Step 6: Place a tally mark for each piece in the appropriate diameter X length class tally box in the "PIECES BRIDGE ABOVE BANKFUL CHANNEL" section of the Thalweg Profile and Woody Debris Form.

Step 7: After all pieces within the segment have been tallied, write the total number of pieces for each diameter X length class in the small box at the lower right hand corner of each tally box.

Step 8: Repeat Steps 1 through 7 for the next stream segment, using the Thalweg Profile and Woody Debris Form.

SITE NAME:								**DATE:**		**VISIT: 1 2**		
SITE ID:								**TEAM ID:**				
LARGE WOODY DEBRIS ≥ 10cm small end diameter; 1.5 m length					CHECK IF ALL UNMARKED BOXES ARE ZERO ☐					FLAG		
Diameter Large end	Pieces All/part In Bankfull Channel						Pieces Bridge Above Bankfull channel					
	Length 1.5-5 m		5-`5 m		> 15 m		Length 1.5-5 m		5-`5 m		> 15 m	
0.1 <0.3 m												
0.3 <0.6 m												
0.6 <0.8 m												
>0.8 m												
TOTAL												

Figure 2. Woody Debris Form

METHOD FOR CHARACTERIZING STREAM MORPHOLOGY, THALWEG PROFILE

Protocol taken from*: Peck et al. (Unpubl.), Table 7-3; Kauffman et al. (1999)*

PURPOSE

The Thalweg profile can detect changes in the stream morphology associated with habitat restoration projects designed to improve pool-riffle relationships, provide velocity changes and other structure beneficial as hiding and holding habitat for salmonids.

EQUIPMENT

Surveyor's telescoping rod, 50 m measuring tape, laser range finder, camera tripod, 2 - ½ in. diameter PVC pipe, 2-3 m long, meter stick, surveyor tape, Bearing compass, fisherman's vest with lots of pockets, chest waders, appropriate waterproof forms.

SITE SELECTION

The sample reaches are those laid out according to the methods on page 12.

SAMPLING DURATION

Sampling should occur during the summer low flow period.

PROCEDURE

The Thalweg Profile is a longitudinal survey of depth, habitat class, presence of soft/small sediment deposits, and off-channel habitat at 100 equally spaced intervals (150 in streams less than 2.5 m wide) along the centerline between the two ends of the sampling reach. "Thalweg" refers to the flow path of the deepest water in a stream channel. Wetted width is measured and substrate size is evaluated at 21 equally spaced cross-sections (at 11 regular Transects A through K plus 10 supplemental cross-sections spaced mid-way between each of these).

Step 1: Determine the interval between measurement stations based on the wetted width used to determine the length of the sampling reach. For widths < 2.5 m, establish stations every 1 m. For widths between 2.5 and 3.5 m, establish stations every 1.5 m. For widths > 3.5 m, establish stations at increments equal to 0.01 times the sampling reach length.

Step 2: Complete the header information on the Thalweg Profile and Woody Debris Form (Figure 2), noting the transect pair (downstream to upstream). Record the interval distance determined in Step 1 in the "INCREMENT" field on the field data form.

NOTE: *If a side channel is present and contains between 16 and 49% of the total flow, establish secondary cross-section transects as necessary. Use separate field data forms to record data for the side channel, designating each secondary transect by checking both "X" and the associated primary transect letter (e.g., XA, XB, etc.). Collect all channel and riparian cross-section measurements from the side channel.*

Step 3: Begin at the downstream end (station "0") of the first transect (Transect "A").

Step 4: Measure the wetted width if you are at station "0", station "5" (if the stream width defining the reach length is 2.5 m), or station "7" (if the stream width defining the reach length is < 2.5 m). Wetted width is measured across and over mid-channel bars and boulders. Record the width on the field data form to the nearest 0.1 m for widths up to about 3 meters, and to the nearest 5% for widths > 3 m. This is 0.2 m for widths of 4 to 6 m, 0.3 m for widths of 7 to 8 m, and 0.5 m for widths of 9 or 10 m, and so on. For dry and intermittent streams, where no water is in the channel, record zero for wetted width.

NOTE: *If a mid-channel bar is present at a station where wetted width is measured, measure the bar width and record it on the field data form.*

Step 5: At station “5” or “7” (see above) classify the substrate particle size at the tip of your depth measuring rod at the left wetted margin and at positions 25%, 50%, 75%, and 100% of the distance across the wetted width of the stream. This procedure is identical to the substrate size evaluation procedure described for regular channel cross-sections A through K, except that for these mid-way supplemental cross-sections, substrate size is entered on the Thalweg Profile side of the field form.

Step 6: At each Thalweg Profile station, use a meter ruler or a calibrated pole or rod to locate the deepest point (the “thalweg”), which may not always be located at mid-channel. Measure the thalweg depth to the nearest cm, and record it on the Thalweg Profile form. Read the depth on the side of the ruler, rod, or pole to avoid inaccuracies due to the wave formed by the rod in moving water.

NOTE: *For dry and intermittent streams where no water is in the channel, record zeros for depth.*

NOTE: *At stations where the thalweg is too deep to measure directly, stand in shallower water and extend the surveyor’s rod, calibrated rod, or pole at an angle to reach the thalweg. Determine the rod angle by resting the laser range finder on the upper surface of the rod and reading the angle on the external scale of the laser range finder. Leave the depth reading for the station blank, and record a “U” flag. Record the water level on the rod and the rod angle in the comments section of the field data form. For even deeper depths, it is possible to use the same procedure with a taut string as the measuring device. Tie a weight to one end of a length of string or fishing line and then toss the weight into the deepest channel location. Draw the string up tight and measure the length of the line that is under water. Measure the string angle with the laser range finder exactly as done for the surveyor’s rod.*

Table 1. EMAP Pool codes taken from Peck et al. (2001) Figure 7.2

POOL FORMING CODES		CHANNEL UNIT CODES	
N	Not a pool	PP	Pool, Plunge
W	Large Woody Debris	PT	Pool, Trench
R	Rootwad	PL	Pool, Lateral Scour
B	Boulder or Bedrock	PB	Pool, Backwater
F	Unknown, Fluvial	PD	Pool, Impoundment
		GL	Glide
	Combinations eg. WR, BR, WRB	RI	Riffle
		RA	Rapid
		CA	Cascade
		FA	Falls
		DR	Dry Channel

Step 7: At the point where the thalweg depth is determined, observe whether unconsolidated, loose (“soft”) deposits of small diameter (<16mm), sediments are present directly beneath your ruler, rod, or pole. Soft/small sediments are defined here as fine gravel, sand, silt, clay or muck readily apparent by "feeling" the bottom with the staff. Record presence or absence in the “SOFT/SMALL SEDIMENT” field on the field data form. Note: A thin coating of fine sediment or silty algae coating the surface of cobbles should not be considered soft/small sediment for this assessment. However, fine sediment coatings should be identified in the comments section of the field form when determining substrate size and type.

Step 8: Determine the channel unit code and pool forming element codes for the station. Record these on the field data form using the standard codes provided in Table 2. For dry and intermittent streams where no water is in the channel, record habitat type as dry channel (DR).

Step 9: If the station cross-section intersects a mid-channel bar, indicate the presence of the bar in the "BAR WIDTH" field on the field data form.

Step 10: Record the presence or absence of a side channel at the station's cross-section in the "SIDE CHANNEL" field on the field data form.

Step 11: Record the presence or absence of quiescent off-channel aquatic habitats, including sloughs, alcoves and backwater pools in the "BACKWATER" column of the field form.

Step 12: Proceed upstream to the next station and repeat Steps 4 through 11.

Step 13: Repeat Steps 4 through 12 until you reach the next transect. At this point, complete Channel/Riparian measurements at the new transect (Section 7.5). Then prepare a new Thalweg Profile and Woody Debris Form and repeat Steps 2 through 12 for each of the reach segments, until you reach the upstream end of the sampling reach (Transect "K").

THALWEG PROFILE FORM										
SITE NAME:						**DATE:**		**VISIT: 1 2**		
SITE ID:						**TEAM ID:**				
TRANSECT (X) A-B B-C C-D D-E E-F F-G G-H H-I I-J J-K										
THALWEG PROFILE								**Increment (m) →**		
Station	**Thalweg Depth cm (XXX)**	**Wetted Width (XX.X)**	**Bar Width**		**Soft/Small sediment (X for yes)**	**Channel Unit Code**	**Pool Form Code**	**Side Channel (X for yes)**	**Flag**	**Comments**
			Y/N	**(XX.X)**						
0										
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
TOTAL										
MEAN										
VAR										
SE										

Figure 3. Thalweg Profile Form

METHOD FOR MEASURING SUBSTRATE

Protocol taken from: ***Peck et al. (Unpubl.), Table 7-7 modified Wolman pebble count***

PURPOSE

Determining the changes in the percentage of fines and embeddedness within the impact and control areas pre- and post-project in order to determine any significant changes.

EQUIPMENT

Meter stick, surveyor's rod, and metric tape.

SITE SELECTION

The sample reaches should be laid out according to page 12.

SAMPLE DURATION

Counts should be taken during summer low flow period when turbidity and visibility is normally at its best. This may not be true for glacial streams.

PROCEDURE

Step 1: Substrate size class is estimated for a total of 105 particles taken at 5 equally-spaced points along each of 21 cross sections. Depth is measured and embeddedness estimated for the 55 particles located along the 11 regular transects A through K. Cross sections are defined by laying the surveyor's rod or tape to span the wetted channel. Riparian vegetation is observed 5 m upstream and 5 m downstream from the cross section transect.

Step 2: Fill in the header information on page 1 of a channel riparian cross-section form. Indicate the cross-section transect. At the transect, extend the surveyor's rod across the channel perpendicular to the flow, with the zero end at the left bank (facing downstream). If the channel is too wide for the rod, stretch the metric tape in the same manner.

Step 3: Divide the wetted channel by 4 to locate substrate measurement points on the cross section. In the "DISTLB" fields of the form, record the distances corresponding to **0% (LFT), 25% (LCTR), 50% (CTR), 75% (RCTR), and 100% (RGT)** of the measured wetted width. Record these distances at transects A-K, but just the wetted width at mid-way cross sections.

Step 4: Place your sharp-ended meter stick or calibrated pole at the LFT location (0 m). Measure the depth and record it on the field data form. (Cross section depths are measured only at regular transects A-K, not at the 10 mid-way cross sections.)

Step 5: Pick up the substrate particle that is at the base of the meter stick (unless it is bedrock or boulder), and visually **estimate its particle size**, according to the following table. Classify the particle according to its median diameter (the middle dimension of its length, width, and depth). Record the size class code on the field data form. (Cross section side of form for transects A-K; special entry boxes on Thalweg Profile side of form for mid-way cross-sections.)

Table 3. Substrate particle classification

Code	Score	Size class	Size range (mm)	Description
RS	6	Bedrock (smooth)	>4000	Smooth surface rock bigger than a car
RR	6	Bedrock (rough)	>4000	Rough surface rock bigger than a car
HP	6	Hardpan		Firm, consolidated fine substrate
BL	5	Boulders	>250 to 4000	Basketball to car size
CB	4	Cobbles	>64 to 250	Tennis ball to basketball size
GC	3.5	Gravel (coarse)	>16 to 64	Marble to tennis ball size
GF	2.5	Gravel (fine)	>2 to 16	Ladybug to marble size
SA	2	Sand	>0.06 to 2	Smaller than ladybug size, but visible as particles – gritty between fingers
FN	1	Fines	<0.06	Silt, Clay, Muck, (not gritty between fingers)
WD	0	Wood	Regardless of size	Wood and other organic particles
OT	0	Other	Regardless of size	Concrete, metal, tires, car bodies, etc.

Step 6: Evaluate substrate embeddedness as follows at 11 transects A-K. For particles larger than sand, examine the surface for stains, markings, and algae. Estimate the average percentage embeddedness of particles in the 10 cm circle around the measuring rod. Record this value on the field data form. By definition, sand and fines are embedded 100 percent, bedrock and hardpan are embedded 0 percent.

Step 7: Move successively to the next location along the cross section. Repeat steps 4 through 6 at each location. Repeat steps 1 through 6 at each new cross section transect.

	SUBSTRATE FORM						
Project #		Date:					
	Station (5 or 7)	**LFT**	**LCTR**	**CTR**	**RCTR**	**RGT**	**FLAG**
A > B							
B > C							
C > D							
D > E							
E > F							
F > G							
G > H							
H > I							
I > J							
J > K							

Figure 4. Substrate Form

METHOD FOR MEASURING RESIDUAL DEPTH

Protocol taken from: ***Peck et al. (Unpubl.), Table 7-6; Kauffman et al. (1999)***

PURPOSE

Using the following methods, the water surface slope and bearing can be determined. These measures can be used to calculate residual pool depth. Residual pool volume is the amount of water that would remain in the pools if there were not flow and the pools were impermeable basins. The intent of measuring this parameter is to show the changes in cross sectional stream complexity typified by pools and riffles.

Slope and bearing are measured using two people by back-sighting downstream between transects.

EQUIPMENT

Surveyor's telescoping stadia rod, 50 m measuring tape, laser range finder, camera tripod, 2 – ½ in diameter PVC pipe, 2-3 m long, surveyor flagging tape, Bearing compass, fisherman's vest with lots of pockets, chest waders, appropriate waterproof forms.

PROCEDURE

Step 1: Stand in the center of the channel at the downstream cross-section transect. Determine if you can see the center of the channel at the next cross-section transect upstream without sighting across land, (i.e. do not short circuit a meander bend). If not you will have to take supplementary slope and bearing measurements.

Step 2: Set up a tripod in shallow water or have one person hold a **stadia rod** at the downstream cross-section transect (or at a supplemental point). Standing tall in a position with your feet as near as possible to the water surface elevation, set the **tripod** extension and mark it with a piece of **flagging tape** at your eye level. Remember the depth of water in which you are standing when you adjust the flagging to eye level.

Step 3: Walk upstream to the next cross-section transect. Find a place to stand at the upstream transect that is at the same depth as where you stood at the downstream transect when you set up the eye level flagging.

Step 4: With the **laser range finder**, site back downstream on your flagging at the downstream transect. Read and record the percent slope in the "MAIN" section on the **Slope and Bearing Form**. Record the "PROPORTION" as 100%.

Step 5: Stand in the middle of the channel at upstream transect, and site back with your **compass** to the middle of the channel at the downstream transect. Record the bearing (degrees) in the "MAIN" section of the Slope and Bearing Form.

Step 6: Retrieve the tripod from the downstream cross-section station and setup at the next upstream transect as described in Step 2.

Step 7: When you get to each new cross-section transect, backsight on the previous transect. Repeat steps 2 through 6 above.

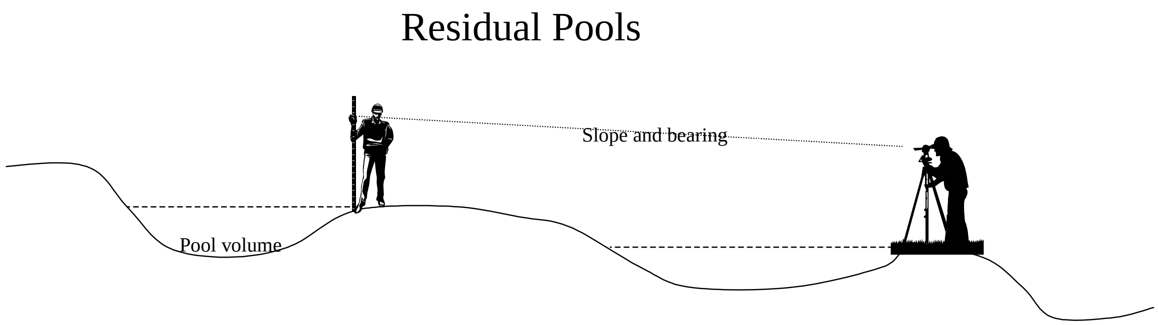

Figure 5. Residual Pools

Project No:		Con/Impact		Sample Year			Date:		Stream	
TRANSECT	**MAIN**			**1^{ST} SUPPLEMENTAL**			**2^{ND} SUPPLEMENTAL**			**FLAG**
	SLOPE XX.X %	**BEARING 0-359**	**BEARING 0-359**	**SLOPE XX.X %**	**BEARING 0-359**	**BEARING 0-359**	**SLOPE XX.X %**	**BEARING 0-359**	**BEARING 0-359**	
A > B										
B > C										
C > D										
D > E										
E > F										
F > G										
G > H										
H > I										
I > J										
J > K										

FLAG	**COMMENTS**

Figure 6. Form for recording residual pool data.

METHOD FOR ESTIMATING INSTREAM JUVENILE SALMONID ABUNDANCE USING ELECTROFISHING

Protocol taken from: ***Zippin (1956); Hankins (1984); Hankins and Reeves (1988)***

PURPOSE

Estimating the density of juvenile salmonids at the project allows the investigator to obtain a sample over time of the change in abundance of rearing juvenile salmonids produced in the stream reach examined. Instead of a randomly selected stream reach, the stream reach impacted by the project is sampled. These "impact" areas are matched with "control" areas of the same length and size on the same stream whenever possible in order to produce a BACI experimental design.

EQUIPMENT

Use a backpack electrofisher consisting of an anode and cathode pole and capable of producing adjustable pulsed D.C. voltage up to 300 volts and an amp meter allowing adjustable amperage up to 1.5 amps. Determine that all team members are wearing waders and gloves, polarized sunglasses, and capture nets. The electrofisher should have automatic current switches in case the operator falls. The electrofisher should be equipped with an audio indicator when the unit is turned on and warning devices when voltage or current exceeds 300 volts or 1.5 amps. Appropriate capture nets and buckets should be available to capture and hold fish.

SITE SELECTION

The sample reaches are those laid out according to the methods on page 12.

Be sure that all collectors' permits and ESA clearances have been obtained before proceeding with electrofishing.

SAMPLING DURATION

Sampling for juvenile abundance should occur during the low flow period in late summer in conjunction with stream morphology measurements. It should be done in one or two days within the same week to avoid changes in conditions, rainfall events, etc.

SAMPLING PROCEDURE

The removal method is based upon the theory that a segment of stream can be fished two or more times to attempt to remove all of the fish and obtain a total count. Because some fish are successful in avoiding capture, a total count cannot normally be obtained. However, a regression equation can be developed that will estimate, with known accuracy and precision, the total number of fish in the sampled reach. The sample team will place blocking nets at the upstream and downstream end of the sample reach in order to reduce escapement of fish from the sample area. Using an electrofisher adjusted for maximum efficiency, the sample reach is covered thoroughly and all fish discovered are captured and placed in buckets for later enumeration. This process is repeated two more times. At the end of the sampling, each pass is enumerated by species and size in order to develop an estimate of the total number of fish within the sampled area using procedures described in Zippin (1956). It is recommended that three passes be used to improve accuracy.

ASSUMPTIONS

The assumptions that underlie the method are:

- o The population is essentially stationary;
- o The probability of capture during a trapping is the same for each animal exposed to capture;
- o The probability of capture remains constant from trapping to trapping.

EFFICIENCY

Although we know that the electrofisher does not catch all of the fish in the sample reach, we assume that the regression reflects the true abundance within the sample reach and that none of the fish were able to escape during sampling.

Turbidity and flow are the dominant factors affecting electrofishing efficiency. Turbid water makes it more difficult to detect and capture fish responding to the electric charge. On the other hand, turbid water is often more conductive and may improve catching efficiency. High flows make it easier for fish to avoid the electric field and to escape downstream.

FISH HANDLING

Sampled fish should be identified as to species and measured for fork length. Fish may be anaesthetized using carbon dioxide.

ESTIMATING TOTAL STREAM REACH POPULATION

Zippin (1956)

Estimating total juvenile population utilizes the following mark recapture formula:

T= Total catch = $\Sigma y_i = y_1 + y_2 + y_3$
where y_i is the number of fish captured on the i^{th} pass.

$\Sigma(I\text{-}1)y_i = (1\text{-}1)y_1 + (2 - 1)y_2 + (3\text{-}1)y_3$
$= y_2 + 2y_3$

Ratio = R = $y_2 + 2y_3 / T$

To obtain the estimated probability of capture during a single capture, one can utilize Zippin's first graph in Figure 2 for three passes or one can use the formula

$R = (q/1\text{-}q) - kq^3/1 - q^3$

N = total population = total catch/estimated proportion of population captured = $T/(1 - q^3)$

The formula for the standard error of the population estimate N is approximately

$$SE(N) = \left[\frac{N(N - T)T}{T^2 - N(N - T)\frac{(kp)^2}{(1 - p)}} \right]^{1/2}$$

METHOD FOR ESTIMATING INSTREAM JUVENILE SALMONID ABUNDANCE USING SNORKELING

Protocol taken from: Rodgers (2002) and Thurow (1994)

PURPOSE

Estimating the density of juvenile salmonids at the project allows the investigator to obtain a sample over time of the change in abundance of rearing juvenile salmonids produced in the stream reach examined. Instead of a randomly selected stream reach, the stream reach impacted by the project is sampled. These "impact" areas have been matched with "control" areas of the same length and size on the same stream whenever possible in order to produce a BACI experimental design.

EQUIPMENT

Persons conducting snorkel counts should be equipped with dry suits or wet suits, masks, snorkels, and rubber soled boots. Additional equipment such as hand counters and underwater white boards are helpful for enumerating fish.

SITE SELECTION

The sample reaches are those be laid out according to the methods on page 12.

Be sure that all collectors' permits and ESA clearances have been obtained before proceeding with electrofishing.

SAMPLING DURATION

Sampling for juvenile abundance should occur during the low flow period in late summer. It should be done in one or two days within the same week to avoid changes in conditions, rainfall events, etc.

SAMPLING PROCEDURE

Step 1: Begin at the downstream boundary of the control or impact study reach as laid out under identified methods and proceed upstream through the pools and riffles. In many smaller streams the riffle areas will be too shallow to snorkel and will contain mostly smaller young of the year trout species.

Step 2: A two person snorkeling crew can conduct snorkel surveys in wadeable stream control and impact study reaches. In areas where the stream is not wadeable, up to four snorkelers may be needed. In wadeable stream reaches, one crew member should snorkel each pool-riffle area while the other crew member records the counts as they are given by the snorkeler. In non-wadeable areas, crew members should snorkel side by side and sum their individual counts. Each snorkeler counts the fish to the immediate front and to the sides opposite the other snorkeler or as designated by the team leader to avoid duplication of counts.

Step 3: In all wadeable and most non-wadeable stream reaches, snorkeling should involve only a single pass through each pool-riffle area.

Step 4: Counts of the number of juvenile salmonids should be recorded for each pool-riffle area. Summer estimates of juvenile salmonids should be limited to age 1+ fish for all species except chinook salmon (>50mm).

Step 5: After snorkeling, the underwater visibility of each study reach is ranked on a scale of 0 to 3 where 0 = not snorkelable due to an extremely high amount of hiding cover or zero water visibility; 1 =

high amount of hiding cover or poor water clarity; 2 = moderate amount of hiding cover or moderate water clarity neither of which were thought to impede accurate fish counts; and 3 = little hiding cover and good water clarity.

Step 6: Only pool-riffles with a visibility rank of two or three should be used in data analysis. The proportion of trout estimated by sample electrofishing that were cutthroat and steelhead should be used to reclassify unknown trout as underwater determination of species is often impossible.

Step 7: Determine pool-riffle area for each reach utilized in Step 1-6 by using the modified Methods for Characterizing Stream Morphology on page 16.

Step 8: For each study reach the number of fish/m2 of pool-riffle habitat can be calculated for chinook, coho, steelhead, and cutthroat by averaging the density estimates for each pool-riffle. A study reach density will be obtained for each species of interest by averaging the individual pool-riffle densities.

Step 9: Consult Thurow (1994) for additional information.

TESTING FOR SIGNIFICANCE

We can create tables resembling the following from the data collected for the indicators for AIS structures (Table 4), stream morphology (Tables 5 and 6), LWD (Table 8), juvenile abundance (Table 10).

Table 4. Number of Intact AIS remaining.

	Year 0 # AIS installed	Year 1	Year 3	Year 5	Year 10
	Impact	**Impact**	**Impact**	**Impact**	**Impact**
Proj. 1					
Proj. 2					
Proj. 3					
Proj. 4					
Proj. 5					
Proj. 6					
Proj. 7					
Proj. 8					
Proj. 9					
Proj.10					
Total					
Percent Remaining	**0**	**100**			

Table 5. Residual pool vertical profile area (AREASUM).

	Year 0 2003		Year 1 2005		Year 3 2006		Year 5 2008		Year 10 2014	
	Impact	**Cntrl**	**Impact**	**Cntrl**	**Impact**	**Cntrl**	**Impact**	**Cntrl**	**Impact**	**Cntrl**
Proj. 1										
Proj. 2										
Proj. 3										
Proj. 4										
Proj. 5										
Proj. 6										
Proj. 7										
Proj. 8										
Proj. 9										
Proj.10										
Mean										
Var.										

Table 6. Mean residual Thalweg depth by project (RP100).

	Year 0 2003		Year 1 2005		Year 3 2006		Year 5 2008		Year 10 2014	
	Impact	**Cntrl**	**Impact**	**Cntrl**	**Impact**	**Cntrl**	**Impact**	**Cntrl**	**Impact**	**Cntrl**
Proj. 1										
Proj. 2										
Proj. 3										
Proj. 4										
Proj. 5										
Proj. 6										
Proj. 7										
Proj. 8										
Proj. 9										
Proj.10										
Mean										
Var.										

STATISTICAL TESTING FOR CHANGES IN THE THALWEG PROFILE

Among all of the measures taken in a Thalweg Profile, two measures demonstrate the greatest precision and signal to noise ratio (Table 7). These are the mean residual Thalweg depth and the residual pool vertical profile area. We wish to test whether the mean residual pool vertical profile area (the cross-sectional area of water that would be contained in pools if no water were flowing) has increased significantly post impact.

The data will be tested using a paired *t*-test. The paired *t*-test is a very powerful test for detecting change because it eliminates the variability associated with individual sites by comparing each stream to itself, that is, at upstream and downstream locations within the same stream. The impact reach and control reach for each stream are affected by the same local environmental factors and local characteristics in the size and depth of pools and riffles in contrast with other stream systems with their own unique environmental conditions. In other words, the two observations of the pair are related to each other.

Because the paired *t*-test is such a powerful test for detecting differences, very small differences may be statistically significant but not biologically meaningful. For this reason, biological significance will be defined as a 20% increase in mean residual depth and residual pool profile area at the impact sites. The statistical test will be one-sided for an Alpha=0.10. We use a one-sided test because a significant decrease in pool area or depth after the impact would not be considered significant, that is, the project would not be considered effective. Therefore, we are not interested in testing for that outcome. The test will be conducted in Years 1, 3, 5, and 10. If the results are significant in any of those years, the instream structure projects will be considered effective.

Our conclusions are, therefore, based upon the differences of the paired scores for the 10 (sampled instream structure projects. Though somewhat confusing, it may be helpful to think of the statistic as the “difference of the differences”. A one-tailed paired-sample *t*-test would test the hypothesis:

H_0 : The mean difference is less than or equal to zero.
H_A : The mean difference is greater than zero.

The test statistic is calculated as:

$$t_{n-1} = \frac{\text{đ} - 0}{S_{\text{đ}}}$$

where
đ = mean of the differences for Year 0 and a subsequent year

$S_{\text{đ}}$ = variance of the differences

$S_{\text{đ}} = S_d / n^{1/2}$ = variance mean

n = number of sites (or site pairs).

The data may also be tested for significance using a linear regression model of the data points for each of the years sampled. This approach requires all sites to be sampled every year; if data for a site is incomplete, it must be excluded from the regression. This approach also requires an approximately normal distribution for the error term.

Table 7. Composite Thalweg variables exhibiting the best all around precision and signal to noise ratios. RMSE = σ_{rep} is the root mean square error. The lower the value, the more precise the measurement. CV σ_{rep} / ”(%) is the coefficient of variation. The lower the number, the more precise the measurement. S/N = $\sigma^2_{st(yr)} / \sigma^2_{rep}$ is the signal to noise ratio. The higher the number, the more that metric is able to discern trends or changes in habitat in single or multiple sites (Kauffman et al., in press, 1999). This table is provided for information purposes only.

Variable	Description	RMSE = σ_{rep}	CV = σ_{rep} / ”(%)	S/N = $\sigma^2_{st(yr)} / \sigma^2_{rep}$
AREASUM	Residual Pool vertical Profile Area (m^2/reach	7.6	25	17
RP100	Mean residual depth for 100 data points m^2/100 m =cm	2.2	19	9

Table 8. Large woody debris (LWD) volume Log_{10} (V1WM100) m^3/100 m.

	Year 0 2003		Year 1 2005		Year 3 2006		Year 5 2008		Year 10 2014	
	Treat	**Cntrl**	**Treat**	**Cntrl**	**Treat**	**Cntrl**	**Treat**	**Cntrl**	**Treat**	**Cntrl**
Proj. 1										
Proj. 2										
Proj. 3										
Proj. 4										
Proj. 5										
Proj. 6										
Proj. 7										
Proj. 8										
Proj. 9										
Proj.10										
Mean										
Var.										

Testing For Significant Changes In The LWD Profile

We wish to test whether large woody debris has increased significantly post impact. LWD can be tested using an analysis of variance pre- and post-project of the $\log_{10}$ transformation of all pieces of LWD in the control and impact areas. This transformation has been shown to have the greatest precision in evaluating LWD sites.

Table 9. Composite variable for LWD exhibiting the best all around precision and signal to noise ratios.

Variable	Description	RMSE = σ_{rep}	CV = σ_{rep} / ”(%)	S/N = $\sigma^2_{st(yr)} / \sigma^2_{rep}$
Log_{10} C1WM100	LWD, all sizes (Pieces/100 m)	0.4	n.a.	7.0

Table 10. Juvenile abundance #/m^2

	Year 0 2003		Year 1 2005		Year 3 2006		Year 5 2008		Year 10 2014	
	Treat	**Cntrl**	**Treat**	**Cntrl**	**Treat**	**Cntrl**	**Treat**	**Cntrl**	**Treat**	**Cntrl**
Proj. 1										
Proj. 2										
Proj. 3										
Proj. 4										
Proj. 5										
Proj. 6										
Proj. 7										
Proj. 8										
Proj. 9										
Proj.10										
Mean										
Var.										

TESTING FOR SIGNIFICANT CHANGES IN JUVENILE ABUNDANCE

We wish to test whether juvenile salmon abundance in terms of numbers per square meter has increased significantly post impact. The number of juveniles per square meter has been shown to be more descriptive than using either linear measures (#/m) or volume measures (#/m^3). The annual variation in numbers is significant as can be seen in Table 11 taken from Bisson et al. (in press).

Table 11. Average coefficient of variation of the inter-annual abundance of adults and juvenile salmonids (Bisson et al.). An asterisk denotes a significant difference (P < 0.10, single classification ANOVA) in comparison with other life stages of that species. The number of populations is shown in parentheses.

Species	Adult	Juvenile	Smolt
Steelhead	60 (3)	66 (6)	50 (5)
Coho	72* (21)	53 (25)	50 (11)
Cutthroat	92 (1)	54 (6)	64 (3)

DATA MANAGEMENT PROCEDURES

Data will be collected in the field using various hand-held data entry devices. Raw data will be kept on file by the project monitoring entity. A copy of all raw data will be provided to the SRFB at the end of the project. Summarized data from the project will be entered into the PRISM database after each sampling season. The PRISM database contains data fields for the following parameters associated with these objectives.

Table 12. PRISM data requirements for Instream Artificial Structure Habitat Projects.

Indicator	Metric	Pre impact Year 0	Post impact Year 1	Post impact Year 3	Post impact Year 5	Post impact Year 10
Stream Distance affected by AIS	miles	√				
Artificially placed instream structures	#		√	√	√	√
AIS Level 1 effective > 80% remaining	Yes/No		√	√	√	√
Thalweg Profile Impact	Mean Residual pool vertical area Mean Stream residual depth	√	√	√	√	√
Thalweg Profile Control	Mean Residual pool vertical area Mean Stream residual depth	√	√	√	√	√
LWD Profile Impact	Log_{10} (C1WM100) pieces/100 m	√	√	√	√	√
LWD Profile Control	Log_{10} (C1WM100) pieces/100 m	√	√	√	√	√
Level 2 effective	Yes/No		√	√	√	√
Juvenile salmon abundance Impact	$\#/m^2$	√	√	√	√	√
Juvenile salmon abundance Control	$\#/m^2$	√	√	√	√	√
Level 3 effective	Yes/No		√	√	√	√

REPORTS

PROGRESS REPORT

A progress report will be presented to the SRFB in writing by the monitoring entity after the sampling season for Years 1, 3, and 5.

FINAL REPORT

A final report will be presented to the SRFB in writing by the monitoring entity after the sampling season for Year 10. It shall include:

- Estimates of precision and variance.
- Confidence limits for data.
- Summarized data required for PRISM database.
- Determination whether project met decision criteria for effectiveness.
- Analysis of completeness of data, sources of bias.

Results will be reported to the SRFB during a regular meeting after 1, 3, 5, and 10 years post project. Results will be entered in the PRISM database and will be reported and available over the Interagency Committee for Outdoor Recreation web site and the Natural Resources Data Portal.

ESTIMATED COST

It is estimated that approximately 73 hours per project would be required to conduct all field activities under the protocol. This results in a relative 2004 cost of $5,600-$9,000 per project.

REFERENCES CITED

Bisson, P.A., S.V. Gregory, T.E. Nickelson, and J.D. Hall. IN PRESS. The Alsea Watershed Study: A comparison with other multi-year investigations in the Pacific Northwest. In J. Stednick and J.D. Hall (editors), The Alsea Watershed: Hydrological and Biological Responses to Temperate Coniferous Forest Practices. Springer-Verlag, New York.

Crawford, B.A., C. Drivdahl, S. Leider, C. Richmond, and S. Butkus (2002). The Washington Comprehensive Monitoring Strategy for Watershed Health and Salmon Recovery. Vol. 2. Olympia, WA. 377p.

Hankins, D.G. (1984). Multistage sampling design in fisheries research: Applications in small streams. Can. J. Fish. Aquat. Sci. 41: 1575-1591.

Hankins, D.G. and G.H. Reeves (1988). Estimating total fish abundance and total habitat area in small streams based on visual estimation methods. Can. J. Fish. Aquat. Sci. 45: 834-844.

Kauffman, P.R., P. Levine, E.G. Robinson, C. Seeliger, and D.V. Peck (1999). Quantifying physical habitat in wadeable streams. EPA/620/R-99/003. U.S. Environmental Protection Agency, Washington, D.C.

Mebane, C., T.R. Maret, R.M. Hughes (2003). An index of biological integrity (IBI) for Pacific Northwest rivers. Trans. Amer. Fish. Soc. 132:239-261.

Peck, D.V., J.M. Lazorchak, and D.J. Klemm (editors). Unpublished draft Environmental Monitoring and Assessment Program -Surface Waters: Western Pilot Study Field Operations Manual for Wadeable Streams. EPA/XXX/X-XX/XXXX. U.S. Environmental Protection Agency, Washington, D.C.

Rodgers, J.D. (2002). Abundance monitoring of juvenile salmonids in Oregon coastal streams, 2001. Mon. Rpt. No. OPSW-ODFW-2002-1. Oregon Dept. Fish and Wildlife. Portland, OR. 51p.

Salmon Recovery Funding Board (2003). Sampling protocols; Effectiveness monitoring requirements. Interagency Committee for Outdoor Recreation. Olympia, WA. 41p.

Stewart-Oaten, A., W.W. Murdoch, and K.R. Parker (1986). Ecology. Vol. 67(4) pp. 929-940.

Thurow, R.F. (1994). Underwater methods for study of salmonids in the Intermountain West. U.S. Forest Service. Gen Tech Rept. INT-GTR-307. 29 p.

Underwood, A.J. (1994). On beyond BACI: Sampling designs that might reliably detect environmental disturbances. Ecological Applications. 4(1):pp 3-15.

Zippin, C. (1956). The removal method of population estimation. Journal of Wildlife Management 22:82-90.